ERDC/CERL CR-12-1

Construction Engineering
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Installation Technology Transfer Program

Feasibility of Energy Crops Grown on Army Lands

The Louis Berger Group, Inc. and Utah State University

March 2012

Feasibility of Energy Crops Grown on Army Lands

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Final report

Approved for public release; distribution is unlimited.

Prepared for U.S. Army
Office of the Army Assistant Chief of Staff for Installation Management (OACSIM)
Washington, DC 20310

Under Contract Number W9132T-11-C-0010

Monitored by Construction Engineering Research Laboratory
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Abstract

This collaborative study by The Louis Berger Group, Inc. and Utah State University demonstrates that land managed by the military could become a significant asset in biofuel production. The viability of renewable oils as a significant fuel source for the U.S. Army (Army) is limited by the availability of feedstocks—a limitation related to the availability of land on which to grow energy crops without impacting food supplies or requiring land use changes. Approximately 1% of Army lands assessed were found compatible with energy crop production. Assuming that the studied sites are typical of Army lands, approximately 150,000 acres of the Army's 15 million acres are compatible with energy crop production. Based on an expected yield per acre of more than 80 gallons, Army lands could potentially yield 12 million gallons of 100% biodiesel per year and replace 20% of its current petroleum diesel consumption with a B20 blend. Growth, harvest, transportation, and storage of these feedstocks could be executed through public-private partnerships. Implementation of this program should be rapid (within 2–4 years) because conventional farming equipment and agricultural practices can be used.

Executive Summary

This collaborative study by The Louis Berger Group, Inc. and Utah State University demonstrates that land managed by the U.S. Army (Army) could become a significant asset in biofuel production. The Army controls approximately 15 million acres of land, and growing biofuel feedstocks on these lands presents an opportunity for the Army to move toward alternative fuel use goals, reduce maintenance and operation costs, and maintain its role as an environmental land steward.

Each gallon of biofuel (B100) grown on post can displace the need for a gallon of petroleum-based fuel. Satisfaction of mandates will follow.

The viability of renewable oils as a significant fuel source for the Army is limited by the availability of feedstocks—a limitation related to the availability of land on which to grow energy crops without impacting food supplies or requiring land use changes. Cultivation of oilseed crops on suitable military lands could support appreciable levels of biodiesel production at reduced production costs attributable to the near elimination of land costs.

This study focused on identifying types of lands common to many Army installations that could be considered for crop production. Any such land use must and would be compatible in all respects with Army mission requirements. Land types potentially suitable for oilseed crop production were identified and include Existing Agricultural Parcels, Grounds Maintenance Areas, Managed Open Spaces, Compatible Training Lands, and Land Rehabilitation and Maintenance Areas. It is intended that the following discussion can be used to evaluate other Army lands for potential use as energy croplands.

Approximately 1% of the Army lands assessed were found compatible with energy crop production. Assuming that the studied sites are typical of Army lands, approximately 150,000 acres of the Army's 15 million acres are compatible with energy crop production. Based on an expected yield per acre of more than 80 gallons, Army lands could potentially yield 12 million gallons of 100% biodiesel per year and replace 20% of its current petroleum diesel consumption with a B20 blend. Therefore, within the limits of

current engine technology, the Army can steadily move to renewable fuel sources and away from petroleum.

It is anticipated that installation personnel will identify additional sites compatible with energy crop cultivation upon further exploration. Biofuel grown on Army lands could meet or exceed annual goals established by Congressional, administrative, and U.S. Department of Defense mandates to reduce petroleum use and introduce new, renewable sources of energy. Growth, harvest, transportation, and storage of these feedstocks could be executed through public-private partnerships. Implementation of this program should be rapid (within 2–4 years) because conventional farming equipment and agricultural practices can be used.

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Preface

This study was conducted for OACSIM under the Installation Technology Transition Program (ITTP), Project number 336870, “Feasibility of Energy Crops Grown on Army Lands.” The technical reviewer for ACSIM was Philip R. Columbus, DAIM-ODF; the ITTP Program Manager was Debbie J. Lawrence, CEERD-CV-T.

The work was performed under Contract W9132T-11-C-0010 by The Louis Berger Group, Inc. and Utah State University. The contract monitor was Ecological Processes Branch (CN-N) of the Environmental Division (CN), U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, William Meyer was Chief, CEERD-CN-N; John Bandy was Chief, CEERD-CN; and Alan Anderson was the Technical Director for Military Ranges and Lands. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Ilker Adiguzel.

COL Kevin J. Wilson was the Commander and Executive Director of ERDC, and Dr. Jeffery P. Holland was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
hectares	1.0 E+04	square meters
miles (U.S. statute)	1,609.347	meters
miles per hour	0.44704	meters per second
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
square miles	2.589998 E+06	square meters
square yards	0.8361274	square meters
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

1 Introduction

In order to reduce the United States' dependence on foreign oil, Congressional, administrative, and U.S. Department of Defense (DoD) mandates set strategic goals and targets for the reduction of petroleum use by non-tactical vehicle fleets. These mandates, as they pertain to vehicle fuels, are summarized in Table 1, Federal Fuel Use Mandates. The baseline for all required reductions is Fiscal Year (FY) 2005 when the DoD non-tactical vehicle fleet consumed 84.8 million (M) gallons of petroleum fuel.

The DoD is required to report its progress toward its energy use targets annually. According to DoD Annual Energy Management Reports, DoD has failed to meet its petroleum fuel reduction targets in FY 2009 and FY 2010. In FY 2009, the DoD used 100 M gallons of vehicle fuel in total-99 M gallons of which was petroleum fuel. Petroleum fuel use in FY 2010 was 80 M gallons-4 M gallons over the mandated reduced consumption target of 76 M gallons.

Most of the Army's fuel reduction thus far has been accomplished through down-sizing its fleet, replacing conventional vehicles with electric vehicles, and shifting from gasoline to diesel and ethanol, which has been facilitated by the development of alternative fueling infrastructure on installations. The DoD's Strategic Sustainability Performance Plan FY 2010 outlines its approach to meeting FY 2011 targets and addressing its reduction backlog by using similar approaches:

1) Increase the use of alternative fuels not based on petroleum by 159% by the end of FY 2015, relative to 2005 levels, as required by EO 13423 §2(g). The Department will do so by continuing to expand the number of alternative fuel vehicles in the fleet and the supporting infrastructure for alternative fuels (through the modification of fueling stations to dispense alternative fuels and the construction of new fueling facilities).

2) Continue to grow the number of low emission and high fuel efficiency vehicles, and encourage personnel to use the most efficient vehicle possible for a given purpose.

3) Downsize ("right-size") the fleet by eliminating unnecessary vehicles.

4) Optimize the operational efficiency of vehicles, by keeping vehicles properly maintained (including tire pressure) and encouraging efficient driving techniques.

The DoD began tracking compliance with energy performance standards in FY 2010 at the installation level to better identify opportunities for improvement. The Plan states, "As DoD holds the Services accountable for their energy performance, we expect the Services to hold their installation commanders accountable for theirs." By the first quarter of FY 2011, the DoD planned to launch a study of approaches that will accelerate its progress in reducing petroleum use by its vehicles, including incorporating the transportation elements of Executive Order (EO) 13423 into relevant position descriptions and performance evaluations.

Table 1. Federal fuel use mandates.

Mandate	Provisions Relevant to Non-tactical Vehicle Fuel Use
Public Law (PL) 109-58, Energy Policy Act of 2005	§701: Vehicles with dual fuel capabilities shall be operated on alternative fuels.
PL 110-140, Energy Independence and Security Act of 2007	§142: A 20% reduction in vehicle petroleum use, and a 10% increase in non-petroleum fuel use annually by 2015 relative to FY 2005. §246: A renewable fuel pump must be installed for every fleet by January 1, 1010, except for DoD fueling centers with a fuel turnover rate > 100,000 gallons/year. §526: Alternative fuels cannot be used if lifecycle greenhouse gas emissions are greater than from conventional petroleum sources.
2007 EO 13423, Strengthening Federal Environmental, Energy and Transportation Management	§2(g) (i): Reduce the fleet's total consumption of petroleum products by 2% annually through the end of FY 2015 relative to FY 2005 (if at least 20 motor vehicles). (ii) A 10% annual increase in the use of non-petroleum fuel, relative to FY 2005. Consume ≥ 50% of renewable energy from new renewable sources.
2009 EO13514, Federal Leadership in Environmental, Energy and Economic Performance	§2a(iii): Reduce the agency fleet's total consumption of petroleum fuel by a minimum of 2% annually through the end of FY 2020, relative to a baseline of FY 2005. §12: Use of biodiesel blends in diesel vehicles. Installation of renewable fuel pumps at Federal fleet fueling centers.
10 USC 2911: Energy Performance Goals and Plan for Department of Defense	DoD shall produce or procure 25% of total energy from renewable energy sources beginning in 2025.
PL 111-84, National Defense Authorization Act of 2010	DoD shall produce or procure 25% of total energy from renewable energy sources beginning in 2025
DoD Strategic Sustainability Performance Plan FY 2010	DoD shall reduce petroleum fuel consumption by 30% compared to the FY 2005 baseline by FY 2020.

1.1 Biodiesel use

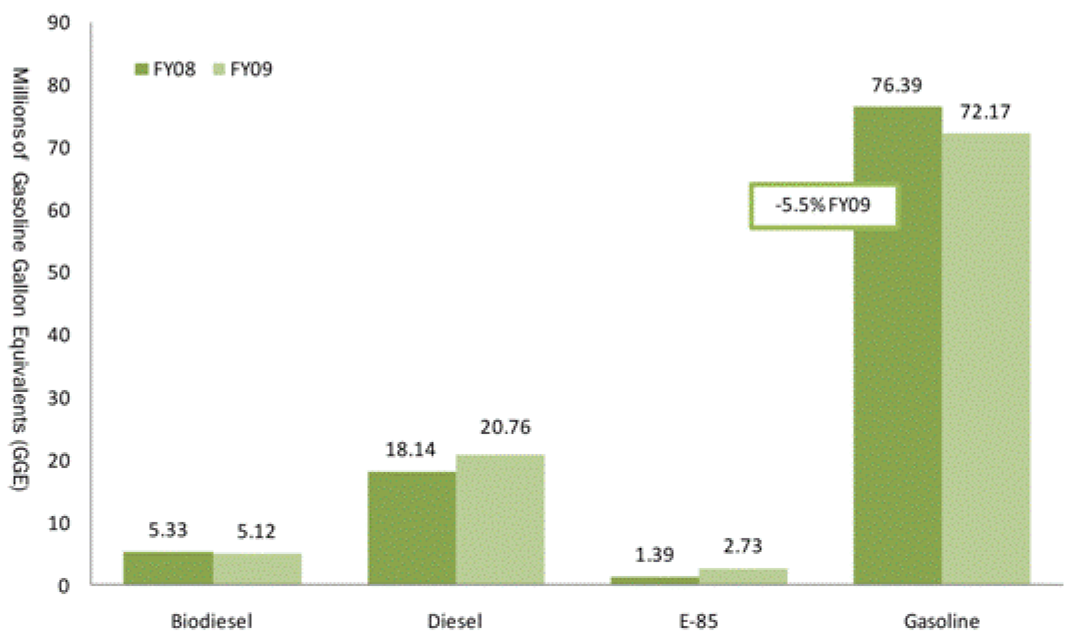
Biodiesel is a fuel refined from vegetable oils that can be used in diesel engines without significant engine modification and therefore can be a "drop-in" replacement for petroleum diesel. Biodiesel fuels are available as 100% biodiesel (B100) or mixed with petroleum diesel to form a blend. Common blends are B20 (20% biodiesel, 80% petroleum diesel) and B5 (5% biodiesel, 95% petroleum diesel). Currently, engine manufacturers recommend using a blend to ensure optimum engine performance and limit nitrous oxide emissions. As of September 2010, a limited number of engines from several manufacturers have been developed to run on B100. However, most engines can handle a B20 blend with a few requiring B5. According to the National Biodiesel Board, all major engine manufacturers in the U.S. market support at least B5 blends, provided they are made with biodiesel meeting American Society for Testing and Materials (ASTM) D 6751, the approved standard for pure biodiesel. More than 60% of U.S. manufacturers now support B20 blends in at least some of their equipment. Several more manufacturers are completing testing and progressing toward support for B20 now that ASTM standards for B5-B20 blends have been published (ASTM D7467).

The U.S. Department of Energy (DoE) guidance for meeting federal mandates includes strategies already in play as well as recommendations to maximize the use of B100 biodiesel or blends above 20% to optimize the use of diesel vehicles, and install biodiesel infrastructure at high-use fueling centers. Although the use of biodiesel actually declined slightly last year, the DoD uses a relatively large quantity, as illustrated in Figure 1, DoD Vehicle Fleet Use by Fuel Type, FY 2008 and FY 2009. Roughly 5.1 M Gasoline Gallon Equivalents (GGE) of biodiesel were used in FY 2009. As a result, the DoD is a significant customer of the biofuels industry, representing 0.6% of the biodiesel market. Use levels at the Army installations included in this report vary from those not using biodiesel to those using more than 100,000 gallons per year. Because all diesel engine vehicles can use at least B5, there is significant potential to increase biodiesel use. Costs and yields are presented below for each installation, along with estimates of how much biodiesel could be used at each of the study installations based on current diesel consumption.

The requirements for biodiesel supply are clearly articulated by the Defense Logistics Agency Energy's (DLA Energy's) Defense Energy Support Center (DESC); biodiesel is generally readily available to any installation

that seeks to increase its use. Biodiesel can be used in any manufacturer specified non-tactical vehicle that uses petroleum diesel and stored in any diesel storage tank (after cleaning it with water) and therefore has no complicated infrastructure requirements. Biodiesel-ready vehicles may, however, require specific fuel formulas, advanced emission control devices to ensure compliance with greenhouse gas emission standards, and proper maintenance per manufacturer's guidance to ensure they meet performance requirements (these actions are part of DoD's 2011 Strategic Sustainability Performance Plan).

Army installations are supplied primarily with biodiesel blends through the DLA Energy procurement process. DoD-certified diesel-supply contractors deliver the requested quantity of biodiesel and meet the specified quality standard. Blends are premixed in the tank. B100 has not been used as a "drop-in" replacement for petroleum diesel pending solution of performance, storage, and greenhouse gas emissions issues. Recent and anticipated advances in fuel formulations are expected to make B100 a viable "drop-in" replacement in the future.



Source: Department of Defense Strategic Sustainability Performance Plan FY 2010 Public Version 26 August 2010

Figure 1. DoD vehicle fleet use by fuel type, FY 2008 and FY 2009.

1.2 Energy crops

Biodiesel can be produced from a wide variety of feedstocks. Crops that have a high energy potential-energy crops-include soy, peanuts, and oilseeds. Oilseed crops are herbaceous flowering plants that have numerous seeds with high oil content, as tabulated in Table 2, Oilseed Crop Properties. These annual plants include rapeseed (Brassica napus, also known as canola, an acronym for Canadian oil low acid), the related field mustard (Brassica rapa), as well as safflower (Carthamus tinctorius), camelina (Camelina sativa), and dwarf sunflower (Helianthus annus). Oil can be extracted from the harvested seeds of these plants and refined to yield a fuel that can replace petroleum diesel. Although biodiesel feedstocks can be produced from other sources such as waste cooking oil, such production is beyond the scope of this report.

Table 2. Oilseed crop properties.

Crop	Planting Season	Days to Maturity	Fertilizer (pounds/acre)	Expected Yield (pounds/acre)	Oil Content
Canola (rapeseed)	Spring and fall	110–140	50 pounds of nitrogen/acre (150 units max.)	1,500–4,000	≈ 38–45%
Field mustard	Spring and fall	95–110	50 pounds of nitrogen/acre (150 units max.)	500–2,000	≈ 35–45%
Safflower	Spring and fall	110–140	50 pounds of nitrogen/acre (150 units max.)	1,500–4,000	≈ 38–45%
Camelina	Spring and fall	85–100	20–50 pounds of nitrogen/acre (150 units max.)	1,500–2,000	≈ 30–35%
Sunflower	Spring	95–110	50 pounds of nitrogen/acre (150 units max.)	1,500–4,000	≈ 35–45%

Oilseed crops can be farmed using conventional tillage and planting equipment or small-scale equipment similar to lawn maintenance tractors. The crops can be harvested with a wheat combine or with compact harvesting equipment. Appendix A, Acceptable Soil Quality Parameters for Oilseed Crop Production, summarizes agronomic requirements for oilseed crops.

1.3 Objectives

The agricultural practices associated with growing and converting biofuel feedstock on traditional agronomic lands are well established. The unique objective of this project is to study the economical and environmental potential for biofuel feedstock production on military lands. Specific goals include: 1) identifying mission-compatible areas at six selected Army installations that potentially are suitable for oilseed production, 2) validating oilseed as a relatively inexpensive renewable energy source, 3) providing a template for a screening process for other Army installations to follow, and 4) suggesting ways to meet Army and other federal mandates to use renewable and alternative energy resources, reduce dependence on foreign oil, and improve energy security and sustainability.

1.4 Approach

A team comprising agronomists, geographers, and landscape architects was formed to meet these objectives. Acknowledging that the primary purpose of Army lands is to ensure the readiness of forces to win this nation's wars, the team focused on identifying types of lands common to most Army installations that could be considered for crop production without interfering with the installation mission. The investigation included extensive discussion with Army personnel to gain a clear understanding of mission-related constraints. A key point during these discussions was that energy crops can be grown on lands that are not traditional agricultural fields, including lands within cantonments. The practice of growing energy crops on "non-traditional lands" has been piloted by Utah State University's Freeways to Fuels program in which crops are grown on road margins, as illustrated in Figure 2, North Carolina Freeways to Fuel Canola Test Crop Site.

Figure 2. North Carolina freeways to fuels canola test crop site.

Potentially suitable lands for oilseed crop production were identified and mapped for each installation based on a review of the documents provided by each installation. Preliminary mapping was discussed with installation personnel in a series of site investigations conducted in May and June 2011. Considering mission requirements and other relevant information, the team identified suitable lands for oilseed crop production at each installation studied. The team collected soil samples at selected sites for further analysis to address soil quality for plant growth.

Installations included in this study were Forts Bragg, Hood, Knox, Leonard Wood, and Polk and the Iowa Army Ammunition Plant (Figure 3). This summary report of the effort includes mapping of the location and extent of appropriate areas for oilseed crops along with the results of a preliminary survey of soil nutrition and growth conditions for biofuel feedstock crops, such as safflower and canola. The information in this report is broad in scope and recommendations may change for individual sites based upon further inspection. The scope of the work completed during this investigation included onsite visual analysis, topsoil sampling and analysis, and recommendations for area use based upon the findings of those analyses.

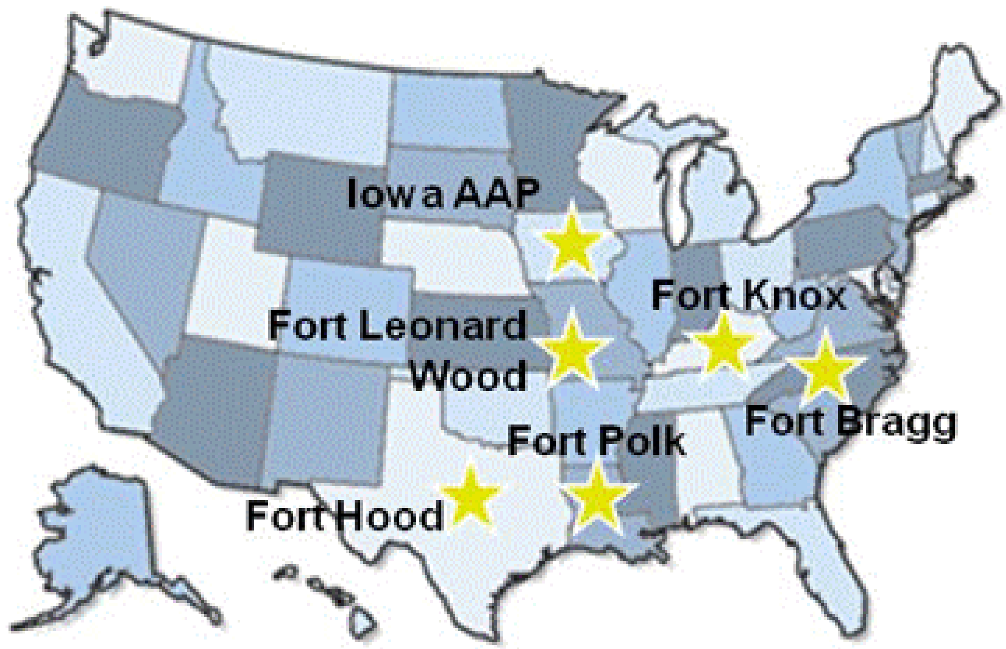


Figure 3. Installations included in the study.

This report recommends appropriate varieties of oilseed crops for each installation; identifies critical times in the crop cycle, such as planting and harvesting; and estimates the likely range of production. The availability of local crushing facilities capable of processing the oilseed feedstock, the cost of processing the crops, and the number of gallons potentially produced are also discussed.

A proposed test site at each of the installations has been identified and is recommended to confirm the agronomic requirements and validate the potential yield of the recommended test crops.

1.5 Mode of technology transfer

This report will be made accessible on the Internet at: http://www.cecer.army.mil.

2 Findings

2.1 Suitability of Army lands

Lands potentially suitable for oilseed crop production were found at four of the six installations visited. At the others, Fort Leonard Wood and Fort Polk, soil conditions suggested that using standard agronomic practices for crop production would be challenging. The team identified the following general land types that are potentially suitable for crop production, and within these land types, the team identified potentially suitable sites:

- Existing Agricultural Parcels,
- Grounds Maintenance Areas,
- Managed Open Spaces,
- Compatible Training Lands, and
- Land Rehabilitation and Maintenance Areas.

The types of suitable lands represent the maximum number of acres at each installation that are potentially suitable for energy crop production. It is intended that installation personnel can use the following information to guide evaluation of their own lands as potential croplands.

Candidate sites were identified at each installation in consultation with installation personnel, drawing on their hands-on knowledge of land use and environmental issues. These potentially suitable sites were identified during a one-day site investigation and represent the minimum number of acres at each installation that are potentially suitable for energy crop cultivation. Not all potentially suitable sites were inspected; therefore, the acreage of suitable sites could be significantly higher. The following describes the steps that were taken to identify potential land for biodiesel crop production.

2.2 Land use analysis

Significant constraints common to all installations include the presence of unexploded ordnance, live fire training activities, mounted maneuvers, forest cover, and other mission requirements that render the majority of each installation unsuitable for energy crop production. These areas were

excluded from consideration. Suitable lands were evaluated based on the following factors:

- land use compatibility,
- soil characteristics,
- accessibility,
- size,
- potential of farming to enhance training,
- potential of farming to reduce maintenance expenses, and
- complexity of the approval process.

The characteristics of suitable land types are summarized below.

2.2.1 Existing agricultural parcels

Agricultural out-leasing is an established practice at Army installations with established procedures for determining leasing and environmental compliance requirements. Oilseed crops can be grown in association with hay fields or integrated into the crop rotation of other crops. Winter and summer annuals, such as canola or safflower, can take the place of soy in a wheat-oat-soy rotation. In some cases, the introduction of an oilseed crop into the rotation improves yield for other crops.

Fort Bragg and Fort Leonard Wood limit their agricultural programs to wildlife forage fields associated with hunting programs with the result being that most current outlease parcels are very small and do not meet the size threshold that the study team used to screen potential sites. Twenty acres is the minimum field size that will produce a yield large enough to make taking the crop to market worthwhile for the farmer. Both installations have attempted in the past to lease fields for hay production without success. The business opportunity has not proven attractive due to the short-lease terms (five years maximum) and the length of time it takes to cultivate a worthy crop of hay (three-four years). Fort Bragg personnel proposed oilseeds as a way to entice farmers to make an additional short-term commitment to developing sustainable hay fields within the installation's extensive drop zones.

2.2.2 Grounds maintenance areas

Grounds maintenance of non-training lands, which is conducted at all Army installations through a combination of contracted maintenance ser-

vices and Army personnel, consists primarily of routine mowing of roadway rights-of-way and medians, clear zones, power line easements, recreation area margins, and building grounds. Bird Anti-Strike Hazard and Anti-terrorism/Force Protection requirements and uses such as parade grounds dictate the maintenance of mowed lawns in some of these areas. Sites that lack requirements for maintaining the land as mowed lawn areas are potentially suitable for oilseed crop production.

Grounds Maintenance Areas offer the possibility of significant direct savings for the Army because the cost of producing an oilseed crop has the potential to defray the cost of many maintenance activities. Oilseed crops can be a suitable replacement for lawns in some areas, such as in medians and roadway margins, around some facilities, and on sites that are vacant pending redevelopment.

2.2.3 Managed open spaces

Each installation is required to manage a range of non-forest land cover types for a variety of reasons, including erosion control and water quality issues, and to prevent encroachment by woody vegetation that renders the land unsuitable for training activities. Standard practices to manage these areas include establishing native grasses, routine mowing by contracted service providers, conducting prescribed burning, and planting wildlife forage crop fields as part of the hunting program. Sites that meet the following criteria are potentially suitable for oilseed crop production:

- Appropriate soil characteristics and topography;
- Accessibility to farm equipment, including smaller planters and harvesters;
- Sufficient size (20 acres minimum) to provide a worthwhile yield for a farmer; and
- Lack of other environmental restrictions or incompatibilities with training activities.

The Army is currently paying to maintain Grounds Maintenance Areas, and oilseed crop production could replace the cost of maintaining these open spaces with an in-kind income.

2.2.4 Compatible training lands

Any land use for energy crops must be compatible in all respects with broader Army mission requirements. All live fire and impact areas were excluded from consideration as potential crop areas. Several types of non-live fire or maneuver training areas are potentially compatible with the production of energy crops with minor modifications to training scheduling to protect the crop from excessive trampling. Drop zones, landing zone perimeters, dismounted or light maneuver areas, and some Military Operations in Urban Terrain (MOUT) training areas are potentially compatible with energy crop production. The typical restrictions that energy crop growth would impose on a MOUT training area include limiting activity to dismounted maneuvers, avoiding heavy use of the training area during the final weeks before crop harvest, excluding grazing cattle or horses, and prohibiting training activity entirely for a total of four weeks each year-one week each at spring and fall planting and harvest times. Each proposed use of land for energy crops will need to be individually analyzed.

Light maneuvers can be conducted in crop fields and can even enhance training realism in some cases. For example, the Range Control Officer at Fort Bragg identified a MOUT training area (Northern Training Area [NTA] IV) that simulates an Afghan or Iraqi village as a desirable site for oilseed crop cultivation. A crop of safflowers, which are native to the Middle East, could better simulate local conditions and improve training realism.

Drop zones can be well suited to energy crop production. There is a history of crop cultivation within drop zones, as illustrated in Figure 4, Drop Zone Dual Use. Although hay production is more appropriate for the center of drop zones when training activity includes aircraft landing and equipment drops, oilseeds can be grown around the perimeter of a drop zone. As noted in the discussion of Managed Open Spaces, the guaranteed income from oilseed crops grown in combination with hay may provide an incentive for a farmer to invest the three to four years required to establish a productive hay field by providing a more immediate source of income.

Figure 4. Drop zone dual use.

2.2.5 Land rehabilitation and maintenance areas

Training activities have a significant impact on the ability of soil to support vegetation. Lands used for training purposes are typically rotated within an installation to allow areas with soil damage to recover. With the exception of the Iowa Army Ammunition Plant, where no on-ground training occurs, all installations studied have extensive areas of damaged soil that are subject to erosion. Land Rehabilitation activities are underway at each installation through Land Rehabilitation and Maintenance (LRAM) programs. The dual purpose of LRAM programs is to sustain training lands in usable condition and protect the environmental quality of the installation. Erosion prevention is an important objective of land rehabilitation activities. Land rehabilitation methods vary by installation and have various rates of success as measured by the establishment of stable vegetative cover and the return of the training area to use.

If integrated into the LRAM program, oilseed crop production can potentially replace or augment many of the currently used LRAM methods. Oilseed crop production could be significantly less costly as an interim use for damaged lands than current methods of restoration and would prepare these lands for more permanent revegetation. Interviews with installation personnel at Fort Knox, for example, indicated that land rehabilitation costs can be as high as $2,000/acre, while the cost of planting, harvesting, storing, and transporting a crop is approximately $200/acre. The departure of the Armor School from Fort Knox leaves approximately 5,000 acres

requiring rehabilitation for a new training mission. Much of the land is heavily impacted by tank training activity, and repair efforts can require several years of soil treatment before a vegetation cover is established.

Mechanized or mounted training activities damage the structure of the soil by removing the topsoil layer, which is essential for nourishing new generations of plants. Additionally these activities can cause compaction of the soil so that it does not drain or retain nutrients. Many current land rehabilitation techniques do not focus on restoring the soil structure required for sustainable long-term rehabilitation of heavily damaged lands. Current methods include bulldozing to level the ground followed by the application of fertilizers and seeding with native plants. In some cases, several attempts are required to establish a stable vegetation cover. Continuous application of fertilizers to damaged soil is not effective in restoring the inherent fertility of land. Of the study installations, Fort Hood's LRAM program includes some form of soil structure restoration.

Farming activities would be an effective way to prepare training areas for final restoration to native vegetation cover. In many cases, bulldozing would not be required.

Crops could be rotated on a long-term basis with grasslands to sustainably manage open training areas at a fraction of the cost of current methods. The integrated cost benefit of crop production requires further analysis but could be significant. Crop production can be a short-term or periodic use for lands that are part of existing rehabilitation "out area" programs (Fort Hood) or that are undergoing rehabilitation as training missions evolve (Fort Knox). Land rehabilitation activities typically are categorically excluded from National Environmental Policy Act (NEPA) analyses; therefore, Land Rehabilitation and Maintenance Areas represent a land use type with high potential for rapid, flexible implementation of oilseed crop production once a Standard Operating Procedure (SOP) has been developed.

Because LRAM areas overlap other categories (Compatible and Incompatible Training Lands and Managed Open Space), they are not included in the total acreage for suitable land types. The potential LRAM areas are totaled separately and require further evaluation.

2.2.6 Ranking of potentially suitable sites

The potentially suitable lands at each installation can be ranked based on how readily they could be put into production. Tier I lands are most suitable to be put rapidly into the production of oilseed crops and meet one of the following criteria:

- There is an existing Environmental Assessment for the site.
- The site is currently cultivated or disturbed, and crop production can be conducted without a lengthy approval process.
- The site can be farmed using the no till/drill method, which does not qualify as a disturbance of the land and therefore does not require a complete Environmental Assessment.

A candidate test site was identified at each installation from among the Tier I sites examined. All suitable sites that do not meet the requirements for Tier I status are ranked as Tier II sites.

Agricultural parcels are typically Tier II sites unless, as at the Iowa Army Ammunition Plant, an existing lease document can be easily updated to include oilseed crops in the requirements. Generally, each potential lease site must undergo an extensive documentation and approval process, including a Report of Availability, an Environmental Condition Survey, and a Record of Environmental Consideration with or without a complete Environmental Assessment. This package would be submitted for legal review and approved through Command Headquarters and Installation Management Command (IMCOM) before being forwarded to the U.S. Army Corps of Engineers for preparation of the final lease document and solicitation. This process can take up to one year if not expedited.

A key component of any agricultural lease is the land use requirements document wherein the agronomic requirements, including fertilizer application rates, are documented. For example, in North Carolina (Fort Bragg), this document must include a Conservation Plan prepared by state resource managers, adding to the length of the approval process. For existing agricultural lease parcels with existing documentation, the land use requirements need only to be updated to include the recommended oilseed crop, fertilization rate, and other agronomic requirements in the Tract Management Plan.

All Land Rehabilitation and Maintenance Areas are ranked as Tier II sites pending the development of an operating procedure that can be readily used by the LRAM coordinator. Currently, LRAM projects require a Work Plan, which is submitted to the Water Management Branch Office, and an Erosion Management Plan. LRAM projects are executed by in-house personnel with contractor support. Projects that require minimal grading followed by seeding or that are considered maintenance projects require no design submittal and may also be categorically excluded from NEPA review.

Several site specific factors should be considered when evaluating potential sites.

- No irrigation is recommended for the oilseed crops proposed in order to limit environmental impact. Only sites with adequate annual rainfall and soil drainage characteristics should be considered.
- Access to some areas may need to be explored further, such as farming machinery access across low-water crossings. Ingress / egress by lessees (farmers) could be an issue at installations (especially AMC) and might reduce out-lease bids.
- Oilseed production in close proximity to airfields or remote stage fields could increase BASH issues, especially after crop harvest. These fields could also conceal animals other than birds that could cause similar issues.
- There may be an increased requirement for herbicide application if converting grassland to annual oil-seed production, so this impact would need to be analyzed. Aerial application of pesticides and scouting for pests (i.e. armyworms) will likely be restricted or not allowed at all on many Army lands. Especially if larger parcels (i.e. 50-100 acres) are available to convert to oil-seed crops, this may have impact the cost of production. On-installation processing is only viable if water resources are available.

In areas such as the Chesapeake Bay watershed, states and EPA are trying to reduce use of fertilizers and their resulting runoff. All agronomic practices would be required to fall under EPA, USDA NRCS guidelines. As indicated in the economic model, tillage practices are recommended to be no-till, which is a low-impact technique and fertilization is recommended to be limited to organic components instead of traditional fertilizers. These recommendations are included in the cost analysis and are intended spe-

cifically to limit the impact of the activity. In locations with nutrient load restrictions, the impact of crop production would need to be evaluated as part of the environmental assessment process. Where nutrient loads are estimated based on land use, the non-traditional agronomic lands identified as suitable land types would likely be excluded from the installation's load calculations. Most oil-seed crops are annual crops which require annual soil manipulation. Many of the Army's soil resources are on highly erodible lands (HEL). While no-till farming is a practice that can reduce erosion with annual crops, many farmers do not possess this equipment. If conventional tillage is used, these efforts should be confined to non-HEL soils.

2.3 Evaluation of installations

Tier I and II lands were evaluated by the study team during site investigations. Tier I sites were selected for soil testing. Soil samples were taken with a standard soil probe made of chrome molybdenum type 4130 steel with a hardened tip and nickel plated for rust resistance. The probe was inserted into the soil approximately 12 inches in depth, and the resultant sample was placed into a poly bucket for mixing with soils from other replications. Ten individual core samples were taken from one representative area to make a composite sample for testing. The following soil analysis methods were used:

- Texture-by feel,
- Soil pH and salinity-1:2 soil:water extract method,
- Organic matter-total Kjeldahl nitrogen method, and
- Phosphorus and potassium-sodium bicarbonate method.

Figure 5 through Figure 10, Potential Oilseed Croplands, identify lands assessed as potentially suitable for energy crop production. Findings for each installation are summarized in the following sections, and complete soil test results are presented in Appendix B, Soil Test Reports.

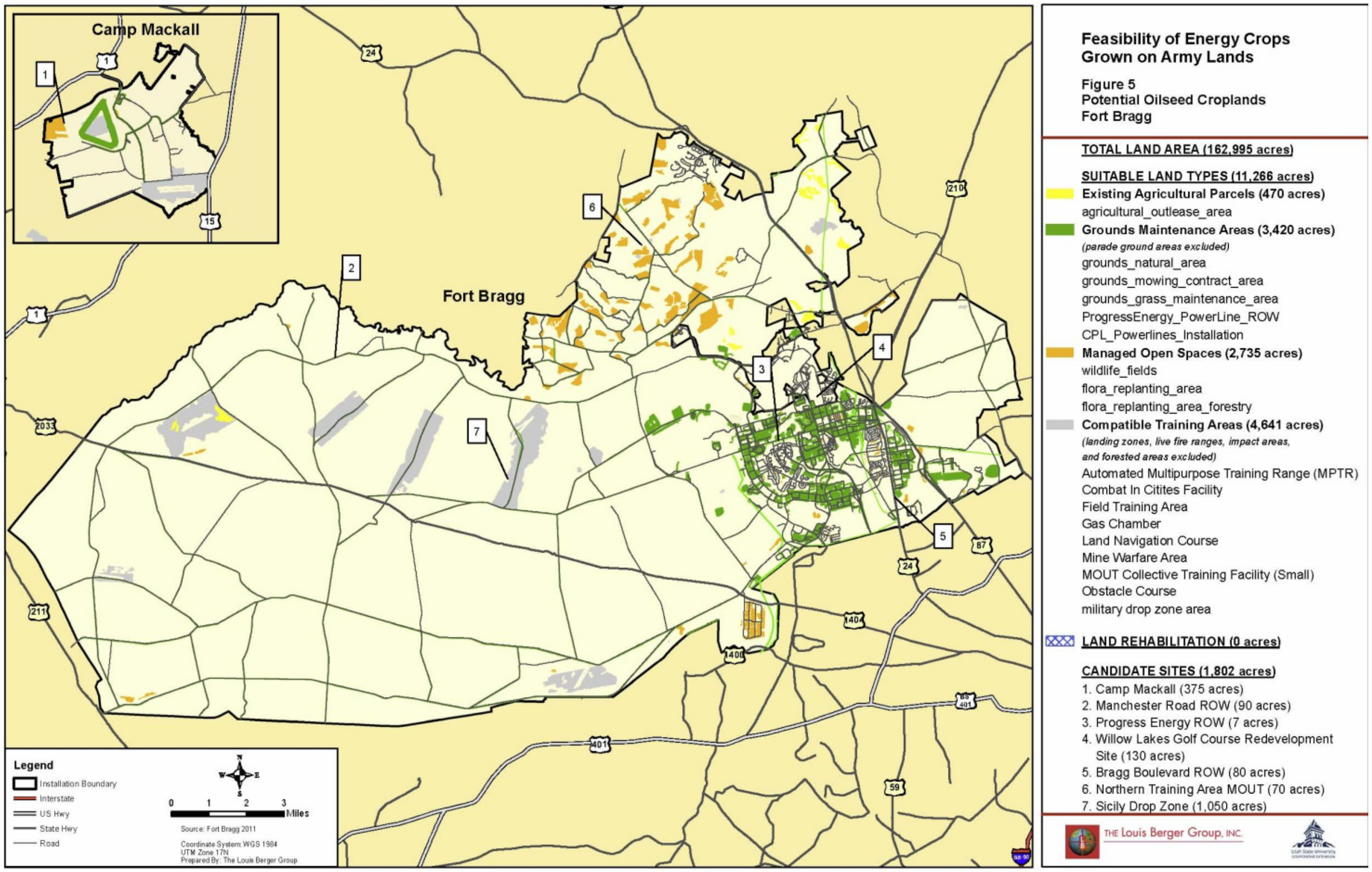


Figure 5. Potential oilseed cropland at Fort Bragg.

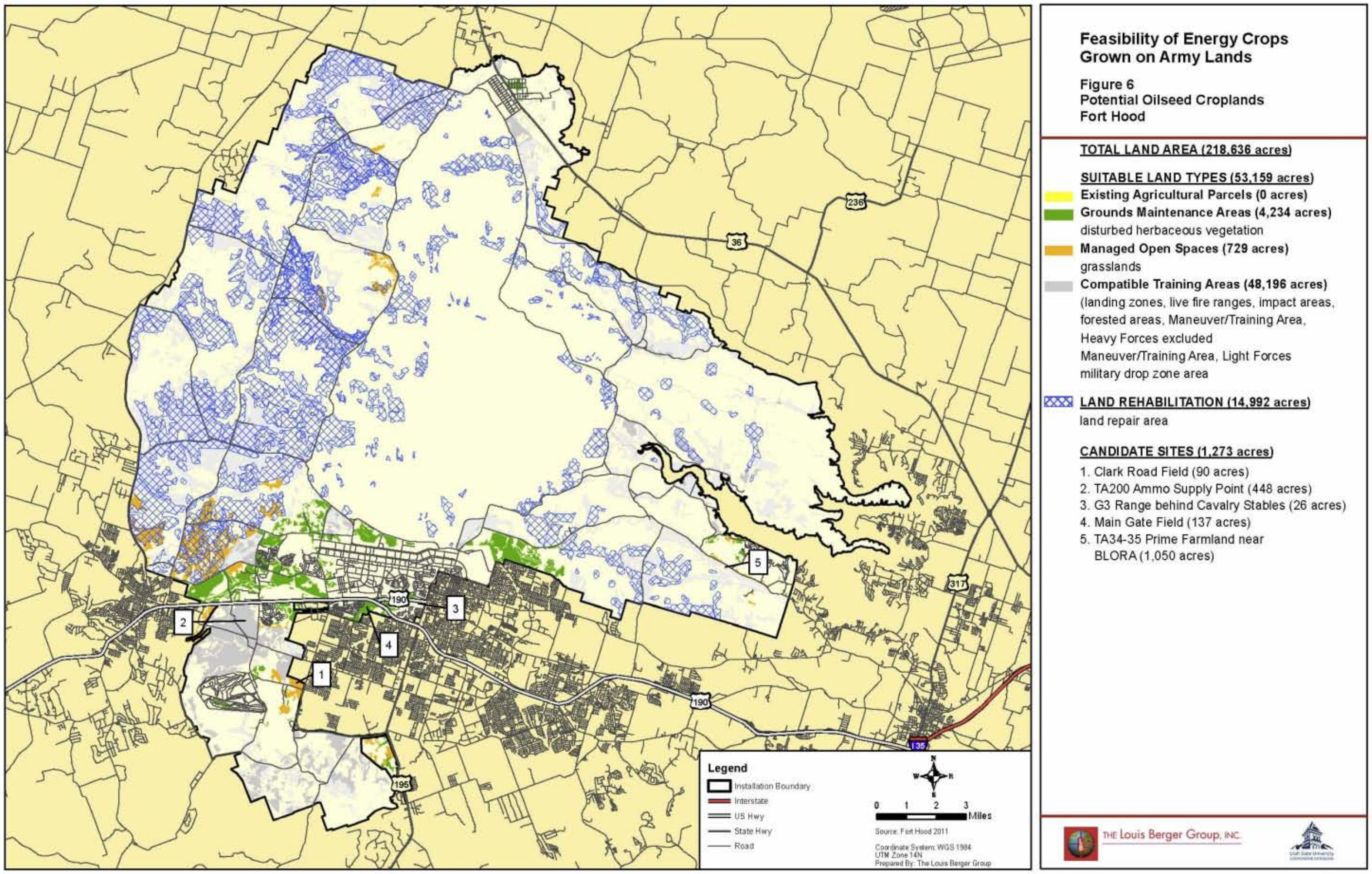


Figure 6. Potential oilseed cropland at Fort Hood.

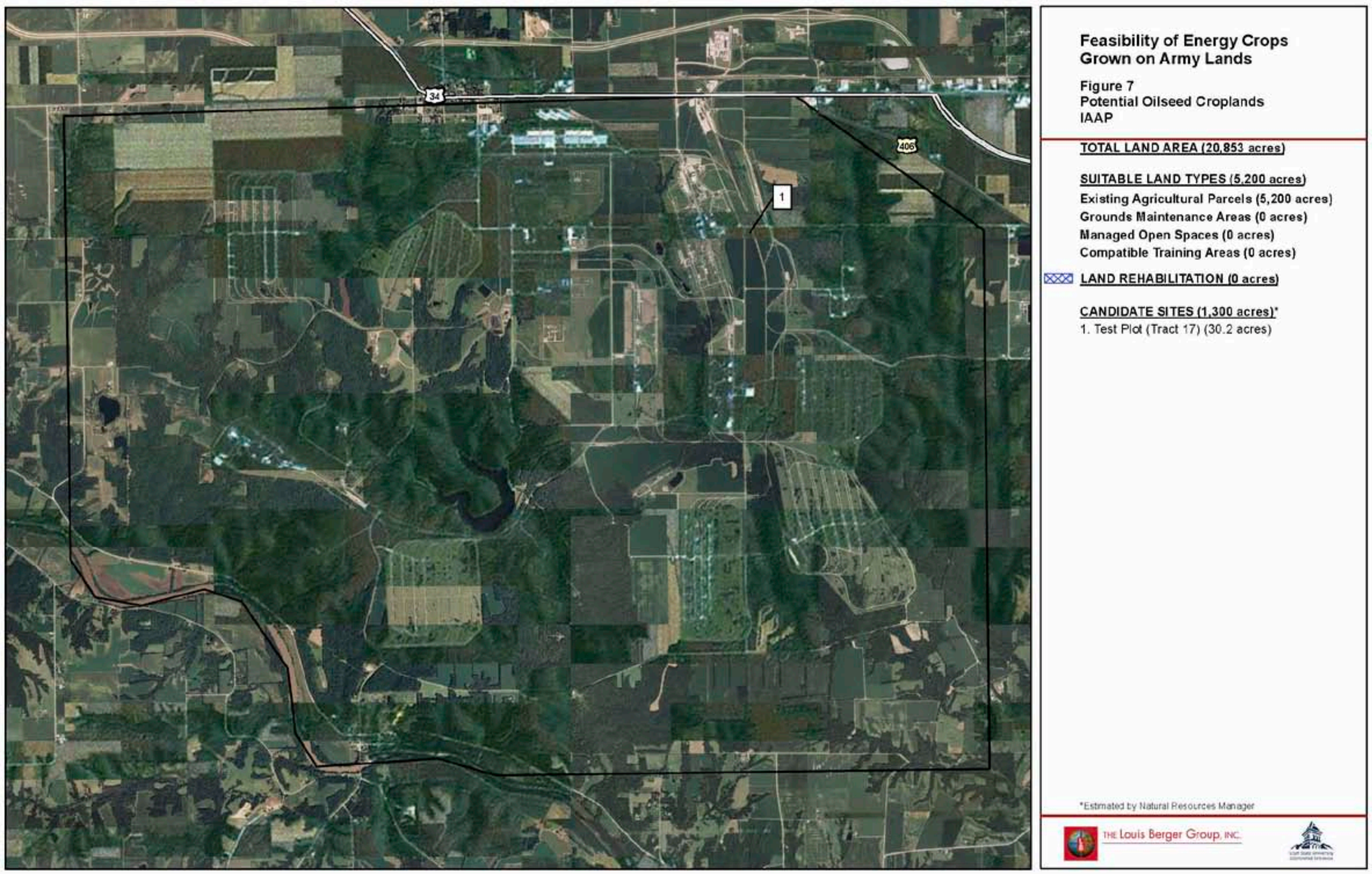


Figure 7. Potential oilseed cropland at IAAP.

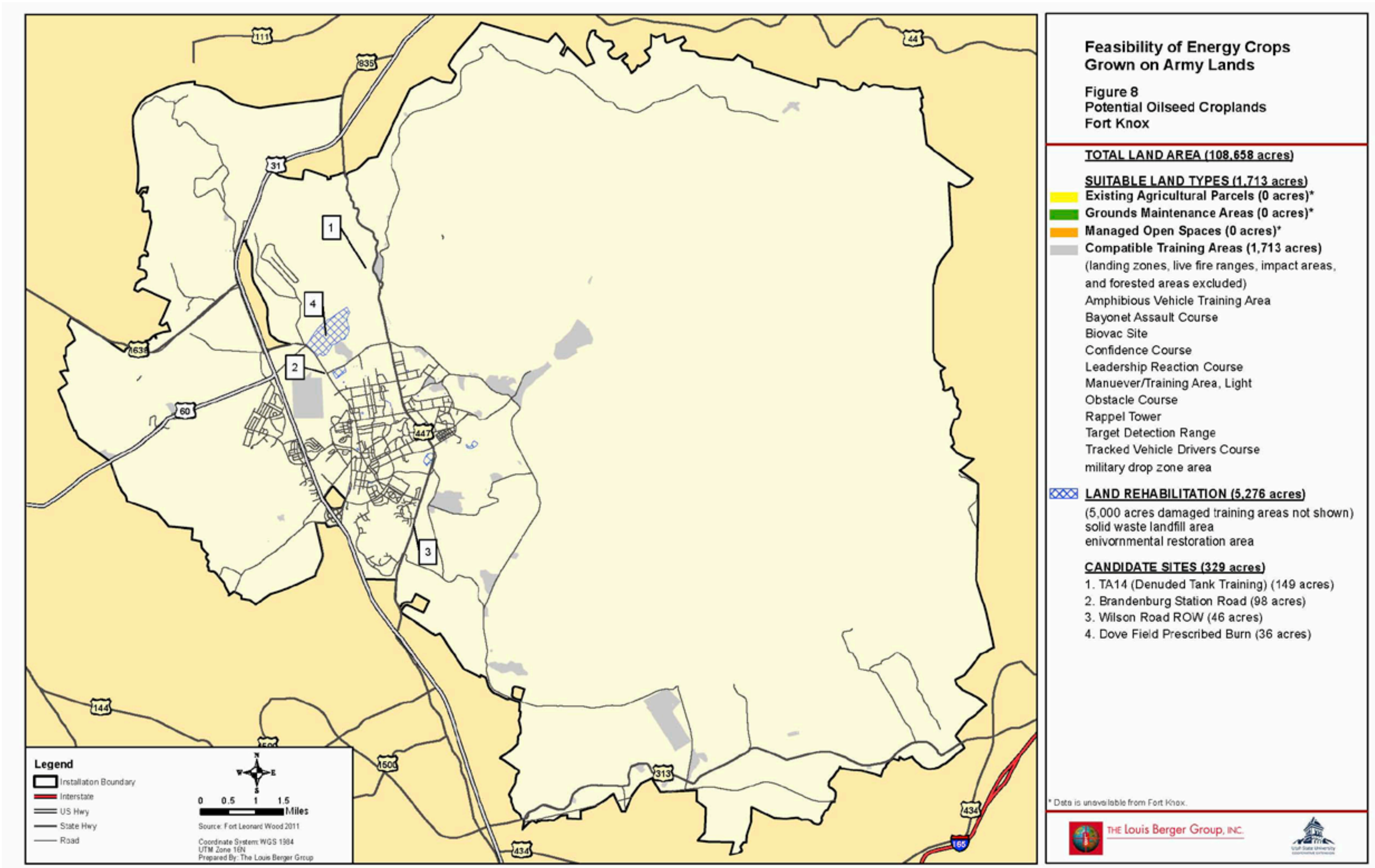


Figure 8. Potential oilseed cropland at Fort Knox.

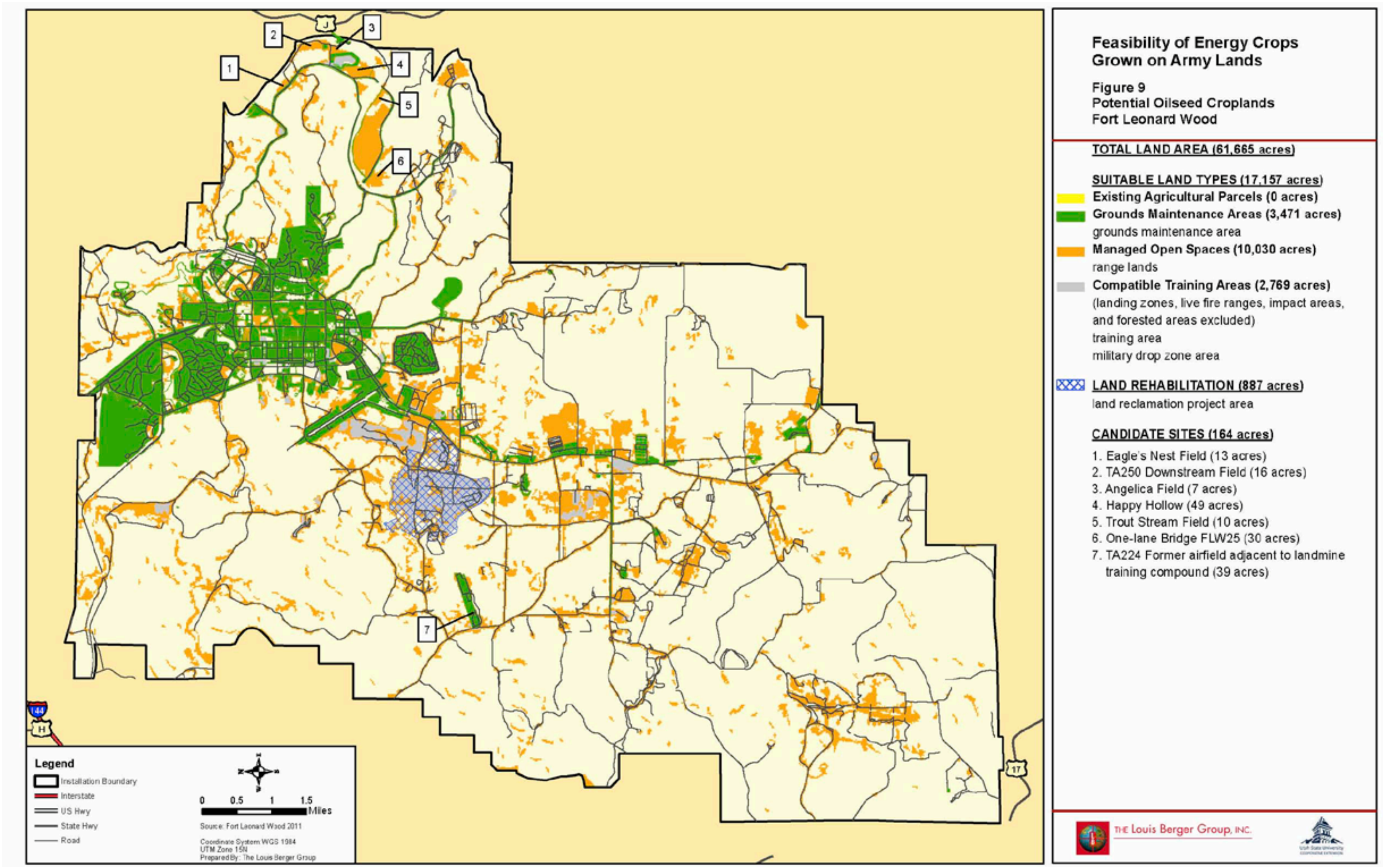


Figure 9. Potential oilseed cropland on Fort Leonard Wood.

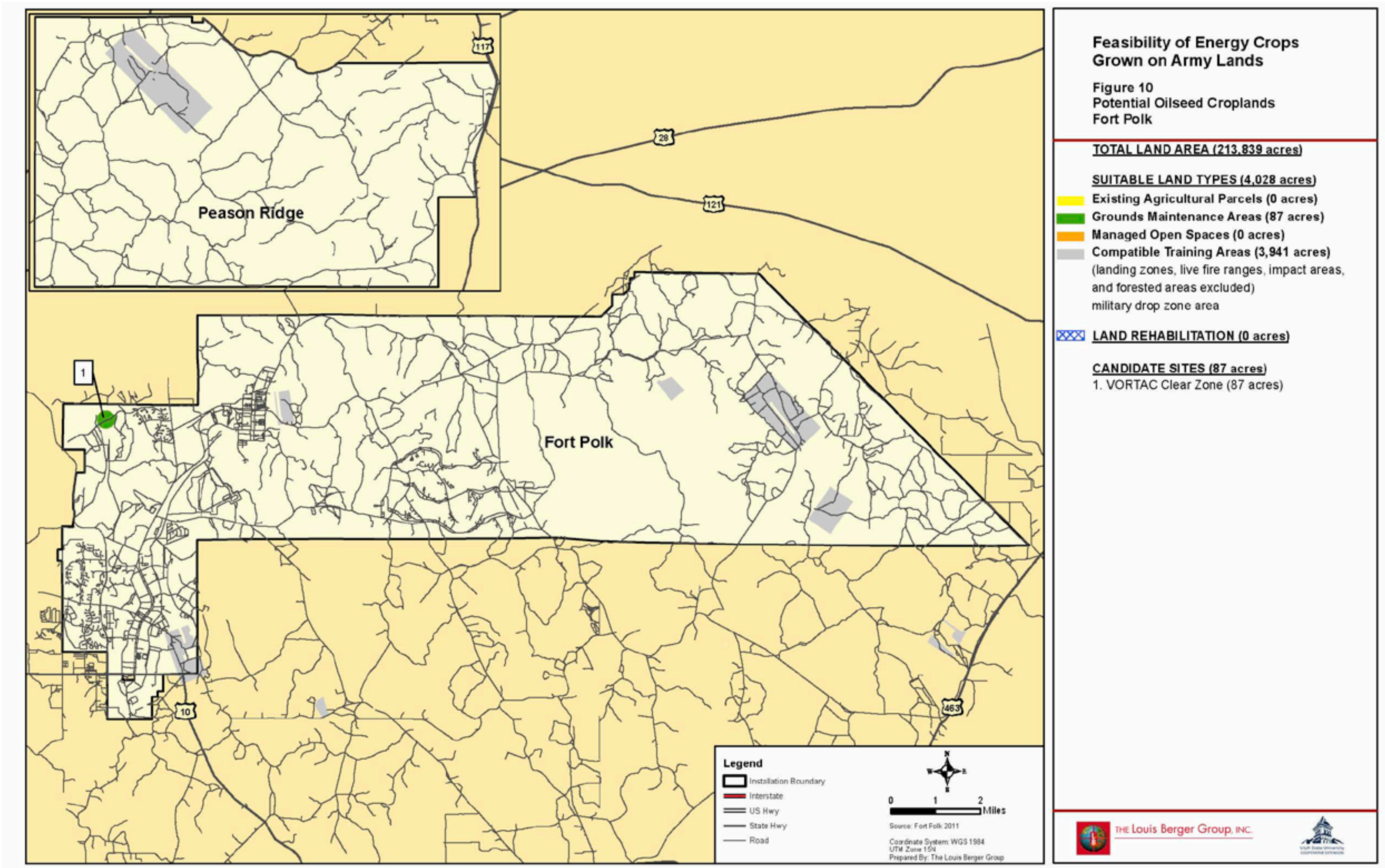


Figure 10. Potential oilseed cropland on Fort Polk.

2.3.1 Fort Bragg, North Carolina

Fort Bragg has high potential for significant oilseed crop production. Suitable lands identified during a site investigation conducted May 9-10, 2011, are illustrated in Figure 5, Potential Oilseed Croplands-Fort Bragg. Seven candidate test sites at Fort Bragg were identified based on topography and access and selected for soil analysis.

Two innovative possibilities were identified by Fort Bragg personnel. As discussed under Existing Agricultural Parcels and Managed Open Spaces, hay cultivation has been considered as a way to reduce the cost of maintaining the installation's approximately 7,000 acres of drop zones. A hay crop requires three or four years of cultivation before an attractive harvest can be realized. Opportunities offered at Fort Bragg for hay cultivation, restricted to five-year maximum leases, have not proven appealing to the local farming community. Energy crops can be grown around the margins of the drop zone or over the entire drop zone. Income from oilseed harvesting would improve the attractiveness of the hay production opportunity by providing a salable harvest during the years required to cultivate the fields. Income from hay and oilseeds would offset or replace the cost of maintenance for drop zones. In cases where equipment drops are prohibited due to urban encroachment, such as at Drop Zone Saint Mere Eglise, oilseeds could be grown over the entire drop zone

As discussed under Compatible Training Lands above, the Range Control Officer at Fort Bragg has identified a MOUT training area, Northern Training Area IV (NTA IV) that simulates an Afghan or Iraqi village as a desirable site for oilseed crop cultivation. A crop of safflowers, which are native to the Middle East, would better simulate local conditions and improve training realism. Although safflowers may simulate local conditions of the Middle East, the oilseed feedstock canola has been successfully grown in the region and would be the crop of choice for this application.

Most of the soils at Fort Bragg are very light in texture (sandy) and devoid of substantial nutrient content and nutrient holding capacity. Because of the texture of the soil and the amount of precipitation the area receives, the pH of the soil is also lower than desired. Both of these conditions could be remedied by application of low-cost organic matter in the form of manure, compost, or biosolids with adjunct conventional fertilizers.

Commercial processing facilities were found to be available within an economically viable distance. Due to procurement regulatory considerations, such commercial entities are not listed in this report. Table 3 summarizes expectations for the production of biofuels at Fort Bragg. A candidate test plot of 20 acres could be considered to allow proof-of-concept in economics, soil enrichment, agronomics, biofuel production and sustainability, as well as training compatibility. Based on soil test results and input from installation personnel, a proposed pilot project is recommended at Site 5, NTA IV MOUT.

Table 3. Costs and yields-Fort Bragg.

Land		
Candidate sites evaluated[1]	1,802 acres	
Recommended test plot size/location	20 acres/Site 6—NTA MOUT “Braggdad”	

Recommended Crops		
Spring planting (April 1–May 1)	Safflower	
Expected yield—pounds of oilseed per acre	2,000	
Or		
Winter planting (September 1–October 1)	Round-up ready canola	
Expected yield— pounds of oilseed per acre	2,000	

Yields[2]	**Expected (spring or fall)**	**Range**
Feedstock—pounds of oilseed per acre	2,000	1,500-4,000
B100— gallons per acre	85.7	59.6-178.8

Costs[2]	**Expected (spring or fall)**	**Range**
Custom farming—per acre	$214.07	$150.00-$300.00
Processing—per acre	$114.81	$79.87-$239.62
Total cost per acre to produce	$328.88	$257.13-$498.20
Adjusted cost per acre to produce[3]	$188.51	$190.6-$280.12

Fuel[4]	**Diesel (B100/DS2)**	**Diesel Blend (B20)**
FY 2010 consumption—gallons	127,233	32,972
FY 2010 market price per gallon	$3.03	
Army grown price per gallon	$2.20[5]	
Savings per gallon to installation	$0.83	
Annual savings based on current consumption	$111,208.63[6]	
Acres required to meet current consumption	1,563 acres[7]	

(*Note: table continues on next page.*)

Assumptions:

Yield, cost, and price estimates are assumed to be constant at all installations pending test plot results·

The opportunity cost associated with displacement of current crops is not reflected in the estimates.

[1] See Figure 5, Potential Oilseed Croplands—Fort Bragg, for candidate test site locations.

[2] See Appendix C, Estimated Costs and Returns—Oilseed Production/Acre on Military Land.

[3] Adjusted cost per acre accounts for the value of seed cake produced during processing, which offsets a portion of the processing cost.

[4] FY 2010 B20 and DS2 consumption and prices as reported in OPORDER 11-297 response. Current DS2 consumption represents demand for B100 when B100 is assumed to be a “drop-in” replacement for DS2. B100 can be used as a “drop-in” replacement in suitable vehicles only. Data on the number/type of Army vehicles that are currently B100-ready are not available. See National Biodiesel Board (2011) for vehicles that are B100-ready. Regardless of the blend used, feedstock (B100) replaces petroleum based diesel on a gallon per gallon basis.

[5] Adjusted cost per acre to produce / B100 yield per acre = ($188.51/acre) / (85.7) = $2.20/gallon. Cost is $2.20 /gallon for all fuel consumed including up to 20% of biodiesel blends. Cost of B20 = (Cost of B100 x 0.2) + (Cost of Diesel x 0.8) = (2.20 x .2) + (3.03 x 0.8) = $2.86/gallon.

[6] Current consumption x Savings per gallon = (127,233 gallons B100 + 32,972 gallons B20/5) = 133,986 gallons x Savings per gallon [0.83) = $111,208.63

[7] Current consumption / gallons per acre = 133,986 gallons / 85.7 gallons/acre = 1,563 acres

2.3.2 Fort Bragg Site 1-Willow Lakes Redevelopment Area

Site 1 is an abandoned golf course (Figure 11). The soil texture is sandy with a 12-inch A horizon (the top level of soil), and the soil is well drained and acidic. The macronutrient levels are low relative to optimum crop production standards, but the organic matter content is good. Site 1 is recommended as an alternate test plot.

Figure 11. Fort Bragg Site 1-Willow Lakes Redevelopment Area.

2.3.3 Fort Bragg Site 2-Powerline right-of-way

Site 2 is located under high power transmission line (Figure 12). The soil texture is sandy with a 12-inch A horizon, and the soil is well drained and strongly acidic. The macronutrient levels are depleted relative to optimum crop production standards, but the organic matter content is relatively good. The pH level is out of range for economical amendment. Site 2 is not a prime candidate for a test plot area.

Figure 12. Fort Bragg Site 2-powerline right-of-way.

2.3.4 Fort Bragg Site 3-Sicily drop zone

Site 3 is a highly disturbed training area that has been mechanically leveled and terraced (Figure 13). The soil texture is sandy with a 12-inch A horizon, and the soil is well drained and mildly acidic. The macronutrient levels are depleted relative to optimum crop production standards, and the organic matter content is low. This site is prime for soil amendments, such as manure, compost, or biosolids, that will raise the pH level and provide the necessary soil structure and nutrients. Site 3 is an excellent candidate for a test plot area due to the current high cost of alternate maintenance, favorable topography, and easy access.

Figure 13. Fort Bragg Site 3—Sicily drop zone.

2.3.5 Fort Bragg Site 4-Manchester Road

Site 4 is a disturbed roadside margin that has been mechanically leveled and terraced (Figure 14). The soil texture is sandy with a 12-inch A horizon, and the soil is well drained and mildly acidic. The macronutrient levels are depleted relative to optimum crop production standards, and the organic matter content is low. This site is prime for soil amendments, such as manure, compost, or biosolids that will raise the pH level and provide the necessary soil structure and nutrients. Site 4 is an excellent candidate for a test plot area due to the current high cost of alternate maintenance, favorable topography, and easy access.

Figure 14. Fort Bragg Site 4—Manchester Road.

2.3.6 Site 5-NTA MOUT

The west side of the site is a slightly disturbed training area that has had some tillage applied in the last decade (Figure 15). This site is maintained to keep vegetation growth to a minimum for mission purposes. The soil texture is sandy with a 12-inch A horizon, and the soil is well drained and mildly acidic. The macronutrient levels are depleted relative to optimum crop production standards, and the organic matter content is low. This site is prime for soil amendments, such as manure, compost, or biosolids that will raise the pH level and provide the necessary soil structure and nutrients. Site 5 is an excellent candidate for a test plot area due to the current high cost of alternate maintenance and the potential to enhance the training realism of the site.

Figure 15. Fort Bragg Site 5—NTA MOUT.

2.3.7 Fort Hood, Texas

Fort Hood has high potential for significant energy crop production. During the site investigation conducted June 7-8, 2011, Fort Hood personnel identified seven sites in the Managed Open Spaces and Compatible Training Lands categories as potentially suitable. Five candidate test sites were identified based on topography and access and selected for soil analysis. An existing cattle grazing lease limits the areas on the installation that can be easily put into production. The suitable sites identified by installation personnel focused on areas within the cantonment that are currently excluded from the grazing lease. Also considered were existing fields located on prime farmland soils along the northern boundary of Training Areas 35-36 that would allow for easy fencing. Lands suitable as energy croplands are illustrated in Figure 6.

Fort Hood offers a unique opportunity to integrate one-pass till and drill crop production into its existing innovative LRAM program. This program currently includes sub-soiling and disking to improve soil structure. Access to the installation's remote out-areas, severe rutting, and the onsite

cattle are significant impediments to rapidly putting this method into production. However, the well-organized LRAM program has a record of implementing innovative restoration techniques in collaboration with agencies at Texas A&M University, making Fort Hood a promising location for further exploration of this strategy.

Energy feedstocks, such as safflower and canola, have been grown successfully in the region and would be the crops of choice for this application. Most of the soils at Fort Hood are heavy (clay), presenting drainage and tillage issues. The addition of organic matter, such as manure, compost or biosolids, would help "lighten" the soil by providing more air and water pore spaces. The organic matter mineralization rates under these conditions are quantifiable and predictable and would allow for biosolid disposal in a sustainable manner. The pH level of the soils is in the normal range for agronomic production, and with conventional fertility inputs, this site could produce a normal yield.

Commercial processing facilities were found to be available within an economically viable distance. Table 1 summarizes expected yields and the costs of biofuel production at Fort Hood. A test plot of 20 acres could be considered to allow proof-of-concept in economics, soil enrichment, agronomy, biofuel production and sustainability, and training compatibility. Based on soil test results and input from installation personnel, a proposed pilot project is recommended at Clark Road field (Figure 16).

Table 4. Costs and yields-Fort Hood.

Land		
Candidate sites evaluated[1]	1,273 acres	
Recommended test plot size/location	20 acres/Site 1–Clark Road Field	
Recommended Crops		
Spring planting (April 1–May 1)	Safflower	
Expected yield—pounds of oilseed per acre	2,000	
Or		
Winter planting (September 1–October 1)	Round-up ready canola	
Expected yield—pounds of oilseed per acre	2,000	
Yields[2]	**Expected (spring or fall)**	**Range**
Feedstock—pounds of oilseed per acre	2,000	1,500-4,000
B100—gallons per acre	85.7	59.6-178.8

(*Note: table continues on next page.)*

Costs[2]	Expected (spring or fall)	Range
Custom farming—per acre	$214.07	$150.00-$300.00
Processing—per acre	$114.81	$79.87-$239.62
Total cost per acre to produce	$328.88	$257.13-$498.20
Adjusted cost per acre to produce[3]	$188.51	$190.6-$280.12

Fuel[4]	Diesel (B100/DS2)	Diesel Blend (B20)
FY 2010 consumption—gallons	65,050	70,731
FY 2010 market price per gallon	$3.03	
Army grown price per gallon	$2.20[5]	
Savings per gallon to installation	$0.83	
Annual savings based on current consumption	$65,732.68[6]	
Acres required to meet current consumption	924[7]	

Assumptions:

Yield, cost and price estimates are assumed to be constant at all installations pending test plot results·

The opportunity cost associated with displacement of current crops is not reflected in the estimates.

1 See Figure 6, Potential Oilseed Croplands—Fort Hood, for candidate test site locations.

2 See Appendix C, Estimated Costs and Returns—Oilseed Production/Acre on Military Land.

3 Adjusted cost per acre accounts for the value of seed cake produced during processing, which offsets a portion of the processing cost.

4 FY 2010 B20 and DS2 consumption and prices as reported in OPORDER 11-297 response. Current DS2 consumption represents demand for B100 when B100 is assumed to be a “drop-in” replacement for DS2. B100 can be used as a “drop-in” replacement in suitable vehicles only. Data on the number/type of Army vehicles that are currently B100-ready are not available. See National Biodiesel Board (2011) for vehicles that are B100-ready. Regardless of the blend used, feedstock (B100) replaces petroleum based diesel on a gallon per gallon basis.

5 Adjusted cost per acre to produce / B100 yield per acre = ($188.51/acre) / (85.7) = $2.20/gallon. Cost is $2.20/gallon for all fuel consumed including up to 20% of biodiesel blends. Cost of B20 = (Cost of B100 x 0.2) + (Cost of Diesel x 0.8) = (2.20 x .2) + (3.03 x 0.8) = $2.86/gallon.

6 Current consumption x Savings per gallon = (65,050 gallons B100 + 70,731 gallons B20/5) = 79,196.20 gallons x (0.83) = $65,732.68

7 Current consumption / gallons per acre = 79,196.20 gallons / 85.7 gallons/acre = 924 acres

2.3.8 Fort Hood Site 1–Clark Road field

Site 1 is fenced and has deep soils and native grass vegetation. Although excluded from the current grazing lease, this site is intermittently grazed by cattle and has a >12-inch A horizon. The soil texture is clayey, and the pH is neutral. The macronutrient levels are depleted relative to optimum crop production standards, and the organic matter content is low. This site is prime for soil amendments, such as manure, compost, or biosolids, that will raise the pH level and provide the necessary soil structure and nutrients. Organic matter will also provide aeration and drainage to heavy textured soil. Site 1 is a good candidate for test plot.

Figure 16. Fort Hood Site 1—Clark Road field.

2.3.9 Fort Hood Site 5-TA 35-36–prime farmland

Site 5 is unfenced and stretches for several miles along a river bottom. This site has native grasses that are intermittently grazed by cattle, and it has a >12-inch A horizon. The soil texture is clayey, and the pH is neutral. The macronutrient levels are depleted relative to optimum crop production standards, and the organic matter content is low. This site is prime for soil amendments, such as manure, compost, or biosolids, that will raise the pH level and provide necessary soil structure and nutrients. Organic matter will also provide aeration and drainage to heavy textured soil. While Site 5 is a good candidate for a test plot area because of its prime farmland soil type careful consideration must be given to its compatibility with and impact on Army mission requirements.

Figure 17. Hood Site 5—TA 35-36–prime farmland.

2.3.10 Iowa Army Ammunition Plant

The Iowa Army Ammunition Plant is ideal for significant energy crop production. Lands potentially suitable were evaluated by the study team during a site investigation conducted June 21, 2011. Installation personnel estimate that current total row crop/hay acres that could be used for oilseed production is around 5,200 acres. If oilseed production were fully integrated into the agriculture program at the Iowa Army Ammunition Plant, installation personnel foresee the availability of up to 1,300 acres annually. It would take five-six years to convert existing leases to biodiesel crop production and reach this level.

Commercial processing facilities were found to be available within an economically viable distance. Table 5 summarizes expectations for biofuels production at the Iowa Army Ammunition Plant. Unlike the other installations considered, the Iowa Army Ammunition Plant maintains an active lease program. The cost advantage of producing energy crops at the Iowa Army Ammunition Plant will be less than at other the installations surveyed because energy crops would need to replace crops that currently produce a strong return to the Army. A test plot of 20 acres could be con-

sidered to allow proof-of-concept in economics, soil enrichment, agronomics, biofuel production and sustainability.

Installation personnel selected a pilot project test site, illustrated in Figure 7, Potential Oilseed Croplands-Iowa Army Ammunition Plant. Tract 17 was offered for lease in August 2011. The following agronomic information was recommended to be integrated into the solicitation's Tract Management Plan: The test plot would require 20-30 acres. Winter and spring round-up ready canola and safflower would be the proposed crops with a yield goal of 2,000 pounds per acre for each crop. No till planting is recommended, and a regular grain head combine would be required for harvest. The recommended herbicide for Round-up Ready canola is glyphosate; while Eptam (or EPTC); trifluralin, sonalan, metolachlor, clethodim (Select Max); and sethoxydim (Poast) are recommended for safflower. Fertilizer needs are 150 units of nitrogen, and 35 units of phosphorus.

Implementation of a test crop program at the Iowa Army Ammunition Plant can be rapidly put into effect and would provide validation of the agronomic requirements for growing energy crops. The candidate test site could be identified in the Tract Management Plan as a study plot.

Table 5. Costs and yields-Iowa Army Ammunition Plant.

Land		
Candidate sites evaluated[1]	1,300 acres	
Recommended test plot size/location	20–30 acres/Tract 17	
Recommended Crops		
Spring planting (April 1–May 1)	Safflower	
Expected yield—pounds of oilseed per acre	2,000	
Or		
Winter planting (September 1–October 1)	Round-up ready canola	
Expected yield—pounds of oilseed per acre	2,000	
Yields[2]	**Expected (spring or fall)**	**Range**
Feedstock—pounds of oilseed per acre	2,000	1,500-4,000
B100—gallons per acre	85.7	59.6-178.8

(*Note: table continues on next page.)*

Costs[2]	Expected (spring or fall)	Range
Custom farming—per acre	$214.07	$150.00-$300.00
Processing—per acre	$114.81	$79.87-$239.62
Total cost per acre to produce	$328.88	$257.13-$498.20
Adjusted cost per acre to produce[3]	$188.51	$190.6-$280.12
Fuel[4]	**Diesel (B100/DS2)**	**Diesel Blend (B20)**
FY 2010 consumption—gallons	Not available	Not available
FY 2010 market price per gallon	$3.03	
Army grown price per gallon	$2.20[5]	
Savings per gallon to installation	$0.83	
Annual savings based on current consumption	Not applicable	
Acres required to meet current consumption	Not applicable	

Assumptions:

Yield, cost and price estimates are assumed to be constant at all installations pending test plot results.

The opportunity cost associated with displacement of current crops is not reflected in the estimates.

1 See Figure 7, Potential Oilseed Croplands—Iowa Army Ammunition Plant, for candidate test site locations.

2 See Appendix C, Estimated Costs and Returns—Oilseed Production/Acre on Military Land.

3 Adjusted cost per acre accounts for the value of seed cake produced during processing, which offsets a portion of the processing cost.

4 FY 2010 B20 and DS2 consumption and prices as reported in OPORDER 11-297 response. Current DS2 consumption represents demand for B100 when B100 is assumed to be a “drop-in” replacement for DS2. B100 can be used as a “drop-in” replacement in suitable vehicles only. Data on the number/type of Army vehicles that are currently B100-ready are not available. See National Biodiesel Board (2011) for vehicles that are B100-ready. Regardless of the blend used, feedstock (B100) replaces petroleum based diesel on a gallon per gallon basis.

5 Adjusted cost per acre to produce / B100 yield per acre = ($188.51/acre) / (85.7) = $2.20/gallon. Cost is $2.20/gallon for all fuel consumed including up to 20% of biodiesel blends. Cost of B20 = (Cost of B100 x 0.2) + (Cost of Diesel x 0.8) = (2.20 x .2) + (3.03 x 0.8) = $2.86/gallon.

2.3.11 Fort Knox, Kentucky

Fort Knox has moderate potential for significant energy crop production. Lands potentially suitable for oilseed crop production were evaluated by the study team during a site investigation conducted June 14-15, 2011. Potential lands were ranked based on suitability for energy crop production, and the sites determined as the most ready to be put into production were selected for soil testing. Lands suitable for energy croplands are illustrated in Figure 8. Four candidate test sites were identified.

Commercial processing facilities were found to be available within an economically viable distance. Table 6 summarizes expectations for biofuel production at Fort Knox. A test plot of 20 acres could be considered to allow proof-of-concept in economics, soil enrichment, agronomics, biofuel production and sustainability, as well as training compatibility. Based on

soil test results and input from installation personnel, a pilot project is recommended at Site 1, Denuded Tank Training Area or Site 2, Brandenburg Station Road Right-of-Way.

Until June 2011, Fort Knox was the home to the Armor School, which used hundreds of acres of land for heavy equipment maneuvers. Damage to the soil structure from this activity is extensive. The standard rehabilitation activities include leveling of deep ruts and tracks with bulldozers and graders and then revegetating the area with native grasses by seeding. This rehabilitation process can cost up to $2,000 per acre and has varied results.

Although the restored training areas are level and support some vegetation, the land is not an optimal natural resource in terms of biological function. The soil structure and compaction have not been restored to optimum levels, water infiltration is impeded, and natural ecosystems are not yet fully operational. In this situation, it is proposed that agronomic activity could remedy both the uneven nature of the area and optimize biological activity. With specific agronomic and cultural practices, the land could be leveled and decompressed with fewer resources than are currently being used. This could result in not only better environmental performance of the area but also lower rehabilitation costs for the Army.

Table 6. Costs and yield-Fort Knox.

Land		
Candidate sites evaluated[1]	329 acres	
Recommended test plot size/location	20 acres/Site 1—Denuded tank training area	
	Site 2-Brandenburg Station Road ROW	
Recommended Crops		
Spring planting (April 1–May 1)	Safflower	
Expected yield—pounds of oilseed per acre	2,000	
Or		
Winter planting (September 1–October 1)	Round-up ready canola	
Expected yield—pounds of oil seed per acre	2,000	
Yields[2]	**Expected (spring or fall)**	**Range**
Feedstock—pounds of oilseed per acre	2,000	1,500-4,000
B100—gallons per acre	85.7	59.6-178.8

(*Note: table continues on next page.)*

Costs[2]	Expected (spring or fall)	Range
Custom farming—per acre	$214.07	$150.00-$300.00
Processing—per acre	$114.81	$79.87-$239.62
Total cost per acre to produce	$328.88	$257.13-$498.20
Adjusted cost per acre to produce[3]	$188.51	$190.6-$280.12

Fuel[4]	Diesel (B100/DS2)	Diesel Blend (B20)
FY 2010 consumption— gallons	112,648	0
FY 2010 market price per gallon	$3.03	
Army grown price per gallon	$2.20[5]	
Savings per gallon to installation	$0.83	
Annual savings based on current consumption	$93,497.84[6]	
Acres required to meet current consumption	1,314 acres[7]	

Assumptions:

Yield, cost and price estimates are assumed to be constant at all installations pending test plot results.

The opportunity cost associated with displacement of current crops is not reflected in the estimates.

1 See Figure 8, Potential Oilseed Croplands—Fort Knox, for candidate test site locations.

2 See Appendix C, Estimated Costs and Returns—Oilseed Production/Acre on Military Land.

3 Adjusted cost per acre accounts for the value of seed cake produced during processing, which offsets a portion of the processing cost.

4 FY 2010 B20 and DS2 consumption and prices as reported in OPORDER 11-297 response. Current DS2 consumption represents demand for B100 when B100 is assumed to be a "drop-in" replacement for DS2. B100 can be used as a "drop-in" replacement in suitable vehicles only. Data on the number/type of Army vehicles that are currently B100-ready are not available. See National Biodiesel Board (2011) for vehicles that are B100-ready. Regardless of the blend used, feedstock (B100) replaces petroleum based diesel on a gallon per gallon basis.

5 Adjusted cost per acre to produce / B100 yield per acre = ($188.51/acre) / (85.7) = $2.20/gallon. Cost is $2.20/gallon for all fuel consumed including up to 20% of biodiesel blends. Cost of B20 = (Cost of B100 x 0.2) + (Cost of Diesel x 0.8) = (2.20 x .2) + (3.03 x 0.8) = $2.86/gallon.

6 Current consumption x Savings per gallon= (112,648 gallons) x (0.83) = $93,497.84

7 Current consumption / gallons per acre = 112,648 gallons / 85.7 gallons/acre = 1,314 acres

2.3.12 Fort Knox Site 1-TA 14–denuded tank training area

Site 1 is highly disturbed, void of any vegetation, and eroded (Figure 18). The soil texture is silty-clayey loam with a non-existent A horizon, and the soil is not well drained; it is highly compacted and rutted. The macronutrient levels of potassium are approaching normal levels, and pH is in the normal range. Organic matter content is low. The site is prime for soil amendments, such as manure, compost, or biosolids, that will provide the necessary soil structure and nutrients. Site 1 is an excellent candidate for a test site due to the high cost of rehabilitation. The soil pH and texture are conducive to the proposed activities, and the addition of organic matter would enhance soil by providing more air and water pore spaces. The pH

level of the soils is in the normal range for agronomic production, and with conventional fertility inputs, this site could produce a normal yield.

2.3.13 Fort Knox Site 2–Brandenburg Station Road right-of-way

Site 2 is a roadside margin outside of an airport runway. The site is maintained to keep vegetation growth to a minimum for aircraft landing purposes. The soil texture is medium and has a 12-inch A horizon, and the soil is well drained and mildly acidic. The macronutrient levels are depleted relative to optimum crop production standards, but organic matter content is relatively normal. Site 2 is prime for soil amendments such as manure, compost, or biosolids, that will raise the pH level and provide the necessary soil structure and nutrients for oilseed crop production.

Figure 18. Fort Knox Site 1—denuded tank training area.

2.3.14 Fort Leonard Wood, Missouri

Fort Leonard Wood has minimal potential for early significant oilseed crop production. Lands potentially suitable for oilseed crop production were evaluated by the study team during a site investigation conducted May 25-26, 2011, but no sites were selected for soil testing. The soils are shallow with less than a 12-inch A horizon; the texture is clayey and the pH is reported to be slightly acidic. The macronutrient levels appear to be depleted relative to optimum crop production standards while the organic matter content appears normal. Soil characteristics, topography, size, and accessibility excluded nine of 16 sites examined from consideration for energy crop production. There are several small acreage sites at Fort Leonard Wood that are potentially suitable based on their location in river bottomlands known to have prime farmland soil types.

Table 7 summarizes potential for biofuels production. Fort Leonard Wood had FY 2010 B20 biodiesel use of 120,340 gallons, and because Missouri is a major center for biofuels production, it is in proximity to many local processing facilities. Given these favorable factors, a test plot of 20 acres could be considered to examine soil enrichment and agronomic advances that could make biofuel production feasible. A test site could be selected from among the candidate sites illustrated in Figure 9.

Table 7. Costs and Yield-Fort Leonard Wood

Land		
Candidate sites evaluated[1]	164 acres	
Recommended test plot size/location	20 acres/Sites 1-6 River Bottomlands	
Recommended Crops		
Spring planting (April 1–May 1)	Safflower	
Expected yield—pounds of oilseed per acre Or	2,000	
Winter planting (September 1–October 1)	Round-up ready canola	
Expected yield—pounds of oilseed per acre	2,000	
Yields[2]	**Expected (spring or fall)**	**Range**
Feedstock—pounds of oilseed per acre	2,000	1,500-4,000
B100—gallons per acre	85.7	59.6-178.8

(*Note: table continues on next page.)*

Costs[2]	Expected (spring or fall)	Range
Custom farming—per acre	$214.07	$150.00–$300.00
Processing—per acre	$114.81	$79.87-$239.62
Total cost per acre to produce	$328.88	$257.13-$498.20
Adjusted cost per acre to produce[3]	$188.51	$190.6-$280.12

Fuel[4]	Diesel (B100/DS2)	Diesel Blend (B20)
FY 2010 consumption—gallons	1,057,737	120,354
FY 2010 market price per gallon	$3.03	
Army grown price per gallon	$2.20[5]	
Savings per gallon to installation	$0.83	
Annual savings based on current consumption	$897,900.47[6]	
Acres required to meet current consumption	12,623 acres [7]	

Assumptions:

Yield, cost and price estimates are assumed to be constant at all installations pending test plot results.

The opportunity cost associated with displacement of current crops is not reflected in the estimates.

1 See Figure 9, Potential Oilseed Croplands—Fort Leonard Wood, for candidate test site locations.

2 See Appendix C, Estimated Costs and Returns—Oilseed Production/Acre on Military Land.

3 Adjusted cost per acre accounts for the value of seed cake produced during processing, which offsets a portion of the processing cost.

4 FY 2010 B20 and DS2 consumption and prices as reported in OPORDER 11-297 response. Current DS2 consumption represents demand for B100 when B100 is assumed to be a “drop-in” replacement for DS2. B100 can be used as a “drop-in” replacement in suitable vehicles only. Data on the number/type of Army vehicles that are currently B100-ready are not available. See National Biodiesel Board (2011) for vehicles that are B100-ready. Regardless of the blend used, feedstock (B100) replaces petroleum based diesel on a gallon per gallon basis.

5 Adjusted cost per acre to produce / B100 yield per acre = ($188.51/acre) / (85.7) = $2.20/gallon. Cost is $2.20 /gallon for all fuel consumed including up to 20% of biodiesel blends. Cost of B20 = (Cost of B100 x 0.2) + (Cost of Diesel x 0.8) = (2.20 x .2) + (3.03 x 0.8) = $2.86/gallon.

6 Current consumption x Savings per gallon = (1,057,737 gallons B100 + 120,354 gallons B20/5) = 1,081,807 gallons x (0.83) = $897,900.47

7 Current consumption / gallons per acre = 1,081,807 gallons / 85.7 gallons/acre = 12,623 acres

2.3.15 Fort Polk, Louisiana

Fort Polk has limited potential for significant oilseed crop production. Lands potentially suitable for oilseed crop production were evaluated by the study team during a site investigation conducted June 16-17, 2011. The majority of Fort Polk is pine woodland. The limited non-forested areas that are potentially compatible with oilseed crop production are currently used for both light and mounted maneuvers, making it unlikely that compatible training areas could be put into production without modifying the training schedule substantially. One site was determined to be potentially suitable for oilseed crop production and selected for soil testing. Lands

suitable as oilseed croplands are illustrated in Figure 10, Potential Oilseed Croplands-Fort Polk.

The potential yield of biodiesel from oilseed crops grown on the installation is summarized in Table 8Costs and yields-Fort Polk.. Processing facilities are some distance from Fort Polk, which may lead to a moderate increase in the cost of production. Given the abundance of forest cover and limited availability of open space, cellulosic biodiesel from forestry waste could be a more viable means of producing a sustainable fuel source on the installation. Both a cellulosic biofuel study and an energy crop test plot of 20 acres could be considered to allow proof-of-concept in economics, soil enrichment, agronomic advances, and biofuel production and sustainability. Based on soil test results and input from installation personnel, a proposed pilot project is recommended at Site 1, VORTAC Clear Zone.

Table 8. Costs and yields-Fort Polk.

Land		
Candidate sites evaluated[1]	87 acres	
Recommended test plot size/location	20 acres/Site 1-VORTAC clear zone	
Recommended Crops		
Spring planting (April 1–May 1)	Safflower	
Expected yield—pounds of oilseed per acre	2,000	
Or		
Winter planting (September 1–October 1)	Round-up ready canola	
Expected yield—pounds of oil seed per acre	2,000	
Yields[2]	**Expected (spring or fall)**	**Range**
Feedstock—pounds of oilseed per acre	2,000	1,500-4,000
B100—gallons per acre	85.7	59.6-178.8
Costs[2]	**Expected (spring or fall)**	**Range**
Custom farming—per acre	$214.07	$150.00-$300.00
Processing—per acre	$114.81	$79.87-$239.62
Total cost per acre to produce	$328.88	$257.13-$498.20
Adjusted cost per acre to produce[3]	$188.51	$190.6-$280.12

(Note: table continues on next page.)

Fuel[4]	Diesel (B100/DS2)	Diesel Blend (B20)
FY 2010 consumption—gallons	221,389	47,903
FY 2010 market price per gallon	$3.03	
Army grown price per gallon	$2.20[5]	
Savings per gallon to installation	$0.83	
Annual savings based on current consumption	$191,477.40 [6]	
Acres required to meet current consumption	2,695 [7]	

Assumptions:

Yield, cost and price estimates are assumed to be constant at all installations pending test plot results.

The opportunity cost associated with displacement of current crops is not reflected in the estimates.

[1] See Figure 10, Potential Oilseed Croplands—Fort Polk, for candidate test site locations.

[2] See Appendix C, Estimated Costs and Returns—Oilseed Production/Acre on Military Land.

[3] Adjusted cost per acre accounts for the value of seed cake produced during processing, which offsets a portion of the processing cost.

[4] FY 2010 B20 and DS2 consumption and prices as reported in OPORDER 11-297 response. Current DS2 consumption represents demand for B100 when B100 is assumed to be a “drop-in” replacement for DS2. B100 can be used as a “drop-in” replacement in suitable vehicles only. Data on the number/type of Army vehicles that are currently B100-ready are not available. See National Biodiesel Board (2011) for vehicles that are B100-ready. Regardless of the blend used, feedstock (B100) replaces petroleum based diesel on a gallon per gallon basis.

[5] Adjusted cost per acre to produce / B100 yield per acre = ($188.51/acre) / (85.7) = $2.20/gallon. Cost is $2.20 /gallon for all fuel consumed including up to 20% of biodiesel blends. Cost of B20 = (Cost of B100 x 0.2) + (Cost of Diesel x 0.8) = (2.20 x .2) + (3.03 x 0.8) = $2.86/gallon.

[6] Current consumption x Savings per gallon = (221,389 gallons B100 + 47,903 gallons B20/5) = 230,696 gallons x (0.83) = $191,477.40

[7] Current consumption / gallons per acre = 230,696 gallons / 85.7 gallons/acre = 2,695 acres

3 Conclusions and Recommendations

3.1 Summary of findings

The findings of this study validate oilseed grown on Army lands as a relatively inexpensive renewable fuel source for the Army. Pilot projects at each installation would confirm that finding. The feasibility of cost-effective planting of energy crops is site and soil specific. Yield, expenses and savings numbers above are dependent on numerous assumptions. Thus, on-the-ground experience in the form of test plots would be needed to confirm assumptions and results. Based on results from the investigation of the six installations included in the study, an estimated 1% of the Army's 15 M acres are suitable for energy crop production. Based on an expected yield per acre of more than 80 gallons, Army lands could potentially yield 12 million gallons of 100% biodiesel per year and replace 20% of its current petroleum diesel consumption with a B20 blend. Each gallon of biofuel (B100) grown on post can displace the need for a gallon of petroleum-based fuel. Therefore, within the limits of current engine technology, the Army can steadily move to renewable fuel sources and away from petroleum. Satisfaction of mandates will follow.

Preliminary economic analysis of the estimated costs and yields indicates that the Army could sustainably produce a substantial portion of its fuel demand at a cost that is less than the current cost for petroleum diesel or B20 biodiesel. As B100-ready vehicles become more available and B100 becomes a "drop-in" replacement for petroleum diesel, there is increased potential for savings.

Growth, harvest, transportation, and storage of oilseed feedstocks could be executed through public-private partnerships. Implementation of this program could be rapid (within two-four years) because conventional farming equipment and cultural practices can be used.

3.2 Recommendations

Realizing the potential of Army lands to sustainably produce renewable fuel for its vehicle fleet will require establishment of an institutional framework that will enable success. Making it someone's job, removing

technical barriers, and attracting private-sector partners will enable progress. Recommendations follow.

Complete Identification of Candidate Sites for Energy Crop Production. In order to validate the conclusions and recommendations of this report, it is recommended that each installation assess the suitable land types described and validate candidate sites for oilseed crop production. Installation staff may identify additional sites within the Suitable Land Types that were not evaluated during the study.

Recommended Pilot Projects. The estimated costs and yields included in this report are based on assumptions about farming and production costs, as detailed in Appendix C, Estimated Costs and Returns-Oilseed Production/Acre on Military Land. All installations were assumed to have similar conditions for the purpose of comparison. Regional differences in costs and yields are likely to exist but are not considered significant for the purpose of this report. To establish the potential to economically produce biofuels on Army lands, it is recommended that one of the candidate sites identified be put into production at each installation to confirm the estimated costs and yields on a local basis. The potential savings to the installation is dependent upon the yield and quality of oilseeds, and that savings cannot be ascertained with certainty without experimental results.

Adjust Targets and Incentives. It is recommended that the achievement of renewable fuel targets be incorporated into the job descriptions and performance metrics for the Garrison Commander and cognizant resource managers at each installation if not already done so. According to the DoD Sustainable Strategy Performance Plan, by the first quarter of FY 2011, the DOD was set to launch a study of approaches that will accelerate its progress in reducing petroleum use by its vehicles, including incorporating the transportation elements of EO 13423 into relevant position descriptions and performance evaluations.

Remove Technical Barriers. Creating a demand within the Army for biodiesel and biodiesel-ready vehicles will encourage industry to move toward meeting the Army's performance expectations. Attention from a volume specifier, such as the Army, will accelerate progress on the lingering emissions, engine performance and warranty, and storage issues just as cutting edge DoD initiatives drive innovation in the development of tactical fuels. The remaining curbs on demand can be expected to diminish and biodiesel

use can be expected to increase relative to other fuel alternatives. This will set the stage for establishing successful partnerships with the private sector and realizing the potential of Army land to in meeting the Army's energy independence goals.

As fuels and engines evolve, the Army should ensure that responsible personnel are provided with accurate information. Research is progressing swiftly and information from one year ago is often out of date. The National Biodiesel Board is working with standards institutes to ensure that ASTM standards address lingering issues as they are solved and that B100 distributors will be able to supply biodiesel that meets performance and emissions standards. Most engine manufacturers provide warranties for their engines that use B20, including 2011 models that introduce this capability for the first time.

Develop a Standard Operating Procedure for Production. Because of the complexity of the production process for biodiesel, cost savings attributable to land availability cannot be captured by the Army unless one entity is responsible for the complete enterprise of planting, harvesting, crushing, refining, storing, and blending or delivering biofuels grown on an installation. Implementation logistics were discussed with personnel at each installation and with IMCOM. The DLA's procurement policies and documents were reviewed to identify requirements for delivering biodiesel to Army installations. Three implementation mechanisms were determined to be options.

As discussed above, several installations maintain active agricultural outlease programs. The ability to produce energy crops on a part of an existing outlease can be feasible and can produce environmentally-friendly fuel feedstocks. However, offsetting current income to the Army may make the opportunity cost of the venture infeasible from a cost perspective. It is not thought currently to be a feasible option.

3.2.1 Option 1: Army fuel production

The first option would be for the Army to develop on-installation refining, blending, and storage capabilities and hire contract farmers to cultivate suitable croplands. Complications involved in creating a separate new mission on post may limit this as a practical alternative.

Two options not involving on-installation production were also considered. Both options would be integrated into the DLA fuel procurement process as illustrated in Figure 19.

3.2.2 Option 2: Enhanced use lease

Under this option, the installation would offer appropriate sites for lease to a biodiesel production enterprise through the Enhanced Use Lease (EUL) process provided for under the authority of 10 USC 2667. This authority allows military installations to lease land and facilities to a private or public entity. Specifically, installations can, among other things, enter into long-term leases where in-kind consideration is received in exchange for use of the land being leased. Options for payment in-kind include:

Goods: The EUL land rent is calculated in terms of oilseed crop yield and returned to the Army installation in the form of biodiesel.

Services: The EUL land rent is calculated in terms of custom farming services required to cultivate non-agronomic lands as part of a maintenance contract or LRAM program.

A biodiesel production enterprise could include any or all stages of biodiesel production: the granary that buys the feedstock crop, the crusher or expeller that extracts oil and produces the byproduct feedcake, and the refiner that processes the oil to produce B100 blendstock and the byproduct glycerol. A farmer could also act as a contracted custom farmer as part of a production enterprise.

3.2.3 Option 3: Custom farming service contract

Under this option, a custom farmer would be hired either directly by the installation or as a subcontractor on a maintenance contract or land rehabilitation contract. The contractor would be paid for services rendered. Under this scenario, the service would not be crop production but the residual effect of crop production on Army lands. Oilseed crops would be a byproduct of the maintenance or restoration activity for which the contractor would be paid regardless of yield. Managed as a standard crop share arrangement, the crop yield in excess of the value of the service contract would remain the property of the Army installation and could be processed by an oilseed processing enterprise (competing through the DLA procurement process) and returned to the Amy installation as biodiesel.

The recommended option for purposes of efficiency as well as avoidance of additional missions within an installation is Option 2.

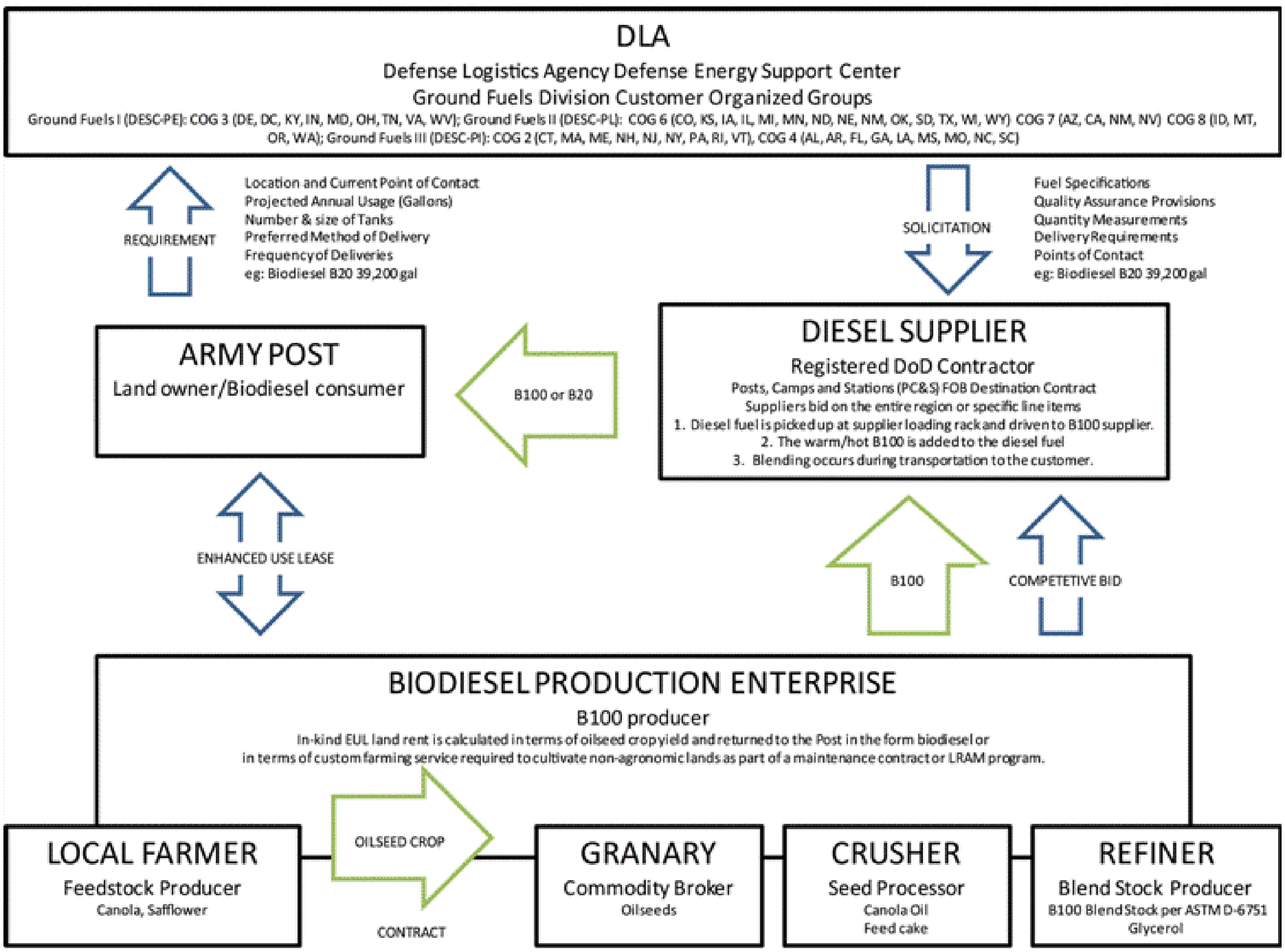


Figure 19. Integration of oilseed production into biofuel procurement.

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Acronyms and Abbreviations

Term	Spellout
ASTM	American Society for Testing and Materials
Army	U.S. Army
ACSIM	Assistant Chief of Staff for Installation Management
b5	5% biodiesel, 95% petroleum diesel
b20	20% biodiesel, 80% petroleum diesel
b100	100% biodiesel
CEERD	U.S. Army Corps of Engineers, Engineer Research and Development Center
CERL	Construction Engineering Research Laboratory
DC	District of Columbia
DESC	Defense Energy Support Center
DLA	Defense Logistics Agency
DLA Energy	Defense Logistics Agency Energy
DoD	U.S. Department of Defense
DoE	U.S. Department of Energy
EO	Executive Order
EPACT	Energy Policy Act (of 2005)
ERDC	Engineer Research and Development Center
eul	enhanced use lease
fy	fiscal year
gge	gasoline gallon equivalents
IMCOM	Installation Management Command
ITTP	Installation Technology Transition Program
LRAM	Land Rehabilitation and Maintenance
M	millions
MOUT	Military Operations in Urban Terrain
NEPA	National Environmental Policy Act
NTA	Northern Training Area
PL	Public Law
SOP	standard operating procedure
U.S.	United States

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY) 30-03-2012

2. REPORT TYPE Final

3. DATES COVERED (From - To)

4. TITLE AND SUBTITLE
Feasibility of Energy Crops Grown on Army Lands

5a. CONTRACT NUMBER W9132T-11-C-0010

5b. GRANT NUMBER

5c. PROGRAM ELEMENT

6. AUTHOR(S)
The Louis Berger Group, Inc. and Utah State University

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
PO Box 9005,
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CERL CR-12-1

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army
Office of the Army Assistant Chief of Staff for Installation Management
Washington, DC 20310

10. SPONSOR/MONITOR'S ACRONYM(S)
OACSIM

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public releasegistribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This collaborative study by The Louis Berger Group, Inc. and Utah State University demonstrates that land managed by the military could become a significant asset in biofuel production. The viability of renewable oils as a significant fuel source for the U.S. Army (Army) is limited by the availability of feedstocks—a limitation related to the availability of land on which to grow energy crops without impacting food supplies or requiring land use changes. Approximately 1% of Army lands assessed were found compatible with energy crop production. Assuming that the studied sites are typical of Army lands, approximately 150,000 acres of the Army's 15 million acres are compatible with energy crop production. Based on an expected yield per acre of more than 80 gallons, Army lands could potentially yield 12 million gallons of 100% biodiesel per year and replace 20% of its current petroleum diesel consumption with a B20 blend. Growth, harvest, transportation, and storage of these feedstocks could be executed through public-private partnerships. Implementation of this program should be rapid (within 2–4 years) because conventional farming equipment and agricultural practices can be used.

15. SUBJECT TERMS
land management, land use, military installations, fuel, biofuel, renewable fuel

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
Unclassified	Unclassified	Unclassified	UU	67	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.1